From: MARTOS Pablo <pablo.martos@state.or.us>
Sent: Tuesday, September 06, 2016 3:12 PM
To: HarborComments
Subject: Mapping Cited in State of Oregon Compiled Comments
Attachments: Harbor_Wide_Map A.PDF

To whom it may concern:

Please find attached the Department of State Lands' Willamette River-Portland Harbor Riparian Line Mapping (March 23, 2016), cited in the compiled comments of the State of Oregon submitted today under separate cover.

Thank you.

Pablo Martos
Portland Harbor Superfund Specialist
Aquatic Resources Management
Department of State Lands

My primary telephone number is 503-856-6621 while we are converting to a new phone system.

1) OLW per Tide Lands Acts of 1872 and 1874 (except in areas of identified shoreline movement as further described in narrative).

2) **UNDER REVIEW.** Post Office Bar Area: Willamette River Harbor Line (as defined by the U.S. Army Corps of Engineers, February 23, 1968) per the November 30, 1987 Quitclaim Deed (Parcel B) from Port of Portland to State of Oregon, recorded in Book 2062, Page 1267, Multnomah County deed records (as corrected by March 28, 1988 Correction Deed, recorded in Book 2092, Page 373, Multnomah County deed records). Note: Current Boundary in this area is the Harbor Line (1968) per this deed, except in those locations where the 1921 USACE map OLW line is shoreward of that Harbor Line, in which case the boundary is the 1921 USACE map OLW line.

2a) **UNDER REVIEW.** 1921 USACE map OLW line.

3) OHW per the June 20, 1967 Quitclaim Deed from State of Oregon to Port of Portland, recorded June 28, 1967 in Book 568, Page 1121, Multnomah County deed records.

3a) OHW per the June 20, 1967 Quitclaim Deed from State of Oregon to Port of Portland, recorded June 28, 1967 in Book 568, Page 1121, Multnomah County deed records (Parcel 3), as clarified by the November 30, 1987 Quitclaim Deed from Port of Portland to State of Oregon, recorded in Book 2062, Page 1267, Multnomah County deed records (as corrected by March 28, 1988 Correction Deed, recorded in Book 2092, Page 373, Multnomah County deed records (Parcel A).

3b) OHW per the June 20, 1967 Quitclaim Deed from State of Oregon to Port of Portland, recorded June 28, 1967 in Book 568, Page 1121, Multnomah County deed records (Parcel 3), as clarified by the November 30, 1987 Quitclaim Deed from State of Oregon, by and through its Division of State Lands, to Port of Portland, recorded in Book 2062, Page 1249, Multnomah County deed records (as corrected by March 31, 1988 Correction Deed, recorded in Book 2092, Page 393, Multnomah County deed records) (Parcel F).

4a) OHW per the November 30, 1987 Quitclaim Deed from State of Oregon, by and through its Division of State Lands, to Port of Portland, recorded in Book 2062, Page 1249, Multnomah County deed records (as corrected by March 31, 1988 Correction Deed, recorded in Book 2092, Page 393, Multnomah County deed records).

4b) OHW per the November 30, 1987 Quitclaim Deed from Port of Portland to State of Oregon, recorded in Book 2062, Page 1267, Multnomah County deed records (as corrected by March 28, 1988 Correction Deed, recorded in Book 2092, Page 373, Multnomah County deed records)

4c) OHW per the November 30, 1987 Quitclaim Deed from Port of Portland to State of Oregon, recorded in Book 2062, Page 1267, Multnomah County deed records (as corrected by March 28, 1988 Correction Deed, recorded in Book 2092, Page 373, Multnomah County deed records) and the November 30, 1987 Quitclaim Deed from State of Oregon, by and through its Division of State Lands, to Port of Portland, recorded in Book 2062, Page 1249, Multnomah County deed records (as corrected by March 31, 1988 Correction Deed, recorded in Book 2092, Page 393, Multnomah County deed records).

5) OHW per the June 26, 2007 Quitclaim Deed from the State of Oregon, by and through its Department of State Lands, to Mar Com Holding LLC, recorded July 12, 2007 as 2007-125605, Multnomah County deed records.

6) OLW per the March 30, 1990 Quitclaim Deed from the City of Portland, by and through the Portland Development Commission, to the State of Oregon, by and through the Division of State Lands, recorded April 12, 1990 in Book 2291, Page 2490, Multnomah County deed records and the March 19, 1990 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to the City of Portland, by and through the Portland Development Commission, recorded April 12, 1990 in Book 2291, Page 2508, Multnomah County deed records.

7) OLW per the March 19, 1990 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands to Crawford Street Corporation, recorded April 12, 1990 in Book 2291, Page 2503, Department of State Lands Deed Records, and the April 10, 1990 Quitclaim Deed from Crawford Street Corporation to the State of Oregon, by and through the Division of State Lands, recorded April 12, 1990 in Book 2291, Page 2497, Multnomah County deed records.

8) OLW per the March 30, 1990 Quitclaim Deed from the City of Portland, by and through the Portland Development Commission, to the State of Oregon, by and through the Division of State Lands, recorded April 12, 1990 in Book 2291, Page 2485, Multnomah County deed records and the March 19, 1990 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to the City of Portland, by and through the Portland Development Commission, recorded April 12, 1990 in Book 2291, Page 2515, Multnomah County deed records.

9) MLW per the December 23, 1991 Quitclaim Deed from Atochem North America, Inc. to the State of Oregon, by and through the Oregon Division of State Lands, recorded in Book 2502, Page 1276, Multnomah County deed records and the January 10, 1992 Quitclaim Deed from State of Oregon, acting by and through the Division of State Lands, to Atochem North America, Inc., recorded in Book 2499, Page 813, Multnomah County deed records.

10) OHW per the May 17, 1979 Bargain and Sale Deed issued by the State of Oregon, by and through the Division of State Lands, to Willamette Western Corporation (north end), recorded May 30, 1979 in Book 1355, Page 1234, Multnomah County deed records and the May 29, 1997 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to Edward Hostmann, Inc., successor plan trustee (south end), recorded as 97081175, Multnomah County deed records .

11) OLW per the January 26, 1993 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to G.S. Roofing Products Company, Inc., recorded March 22, 1993 in Book 2663, Page 1664, Multnomah County deed records and the December 22, 1992 Quitclaim Deed from G.S. Roofing Products Company, Inc. to the State of Oregon, by and through the Division of State Lands, recorded February 3, 1993 in Book 2645, Page 872, Multnomah County deed records.

12) OLW per the October 31, 1991 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to Shell Oil Company, recorded December 2, 1991 in Book 2482, Page 1178, Multnomah County deed records and the November 11, 1991 Quitclaim Deed from Shell Oil Company to the State of Oregon, by and through the Division of State Lands, recorded December 2, 1991 in Book 2482, Page 1176, Multnomah County deed records.

13) Line established by the November 30, 1987 Quitclaim Deed from Port of Portland to State of Oregon (Parcel A), recorded in Book 2062, Page 1267, Multnomah County deed records (as corrected by March 28, 1988 Correction Deed, recorded in Book 2092, Page 373, Multnomah County deed records) with additional clarification of the boundary by the December 30, 1998 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to the Port of Portland, recorded as 2000-105908, Multnomah County deed records.

14) OLW per the July 13, 1993 Special Warranty Deed from the State of Oregon, by and through its Division of State Lands, to Gunderson Inc., recorded July 14, 1993 in Book 2722, Page 2, Multnomah County deed records.

15) OHW per the July 20, 1990 Quitclaim Deed from the State of Oregon, by and though the Division of State Lands, to Texaco Refining and Marketing, Inc., recorded October 29, 1990, in Book 2357, Page 1084, Multnomah County deed records and the July 5, 1990 Quitclaim Deed from Texaco Refining and Marketing, Inc. to the State of Oregon, by and though the Division of State Lands, recorded October 29, 1990, in Book 2357, Page 1086, Multnomah County deed records. \

16) OHW per the December 2, 1987 Bargain and Sale Deed from the State of Oregon, by and through its Division of State Lands, to the Port of Portland, recorded December 2, 1987 in Book 2062, Page 1262, Multnomah County deed records (as corrected by a March 31, 1988 Correction Deed, recorded April 4, 1988 in Book 2092, Page 384, Multnomah County deed records), and the January 11, 1990 Bargain and Sale Deed from the State of Oregon, by and through its Division of State Lands, to the Port of Portland, recorded in Book 2268, Page 1158, Multnomah County deed records.

17a) OHW per the December 2, 1987 Bargain and Sale Deed from the State of Oregon, by and through its Division of State Lands, to the Port of Portland, recorded December 2, 1987 in Book 2062, Page 1262, Multnomah County deed records (as corrected by a March 31, 1988 Correction Deed, recorded April 4, 1988 in Book 2092, Page 384, Multnomah County deed records).

17b) OHW per the Correction Deed from the State of Oregon, by and through its Department of State Lands, to the Port of Portland recorded June 18, 2013 as 2013-082909, Multnomah County deed records. Deed corrects March 31, 1988 Correction Deed recorded April 4, 1988 in Book 2092, page 393 (see note 4a).

18) OLW per the March 27, 1991 Quitclaim Deed from Phoenix Mutual Life Insurance Company to the State of Oregon, recorded May 6, 1991 in Book 2410, Page 1246, Multnomah County deed records and the March 27, 1991 Quitclaim Deed from the State of Oregon, by and through the State Land Board, by the Director of the Division of State Lands, to Phoenix Mutual Life Insurance Company, recorded May 6, 1991 in Book 2410, Page 1244, Multnomah County deed records.

19) OLW per the August 17, 2000 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to the City of Portland, by and through the Portland Development Commission, recorded August 18, 2000 as 2000-114884, Multnomah County deed records.

20) OLW per the February 15, 1989 Quitclaim Deed from Norcrest China Company to the State of Oregon, by and through the Division of State Lands, recorded February 16, 1989 in Book 2179, Page 1105, Multnomah County deed records and the January 31, 1989 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to Norcrest China Company, recorded February 16, 1989 in Book 2179, Page 1109, Multnomah County deed records

21) OLW per the September 26, 1980 Quitclaim Deed from Norcrest China Company to the State of Oregon, by and through the Division of State Lands, recorded December 24, 1980 in Book 1472, Page 1735, Multnomah County deed records and the September 26, 1980 Quitclaim Deed from the State of Oregon, by and through the Division of State Lands, to Norcrest China Company, recorded September 29, 1980 in Book 1472, Page 1708, Multnomah County deed records.

22) Known filled lands claim asserted but not yet resolved.

23) MLW per the June 11, 2014 Quitclaim Deed from the State of Oregon, by and through its Department of State Lands, to Portland Harbor Holdings II, LLC recorded June 18, 2014 as 2014-058177, Multnomah County deed records.

24) Filled, formerly submerged land, unresolved.

25) 1973 MLW as depicted in Port of Portland survey, dated March 26, 1973. DSL has determined that this survey depicts the current riparian boundary at Tax Lot 1N1E17CA-0600, that boundary being the natural OLW line as it existed before the shoreline was dredged back in the early-1970s. This parcel was conveyed to the OLW line by the Port of Portland to Fred Devine Diving & Salvage, Inc., by warranty deed dated September 11, 1973, recorded September 17, 1973 in Book 949, Page 842, Multnomah County deed records (Multnomah County). The riparian boundary at Tax Lot 1N1E17CA-0600 has not been clarified yet by a deed from the State.

WILLAMETTE RIVER-PORTLAND HARBOR
RIPARIAN LINE MAPPING
OREGON DEPARTMENT OF STATE LANDS

A PORTION OF TOWNSHIPS 2N 1W, 1N 1W, AND 1N 1E
WILLAMETTE MERIDIAN
CITY OF PORTLAND, MULTNOMAH COUNTY, OREGON

DAVID EVANS AND ASSOCIATES INC.
2100 Southwest River Parkway
Portland Oregon 97201
Phone: 503.223.6663

REVISIONS: APPD.

DATE: MARCH 23, 2016
DESIGN: JSW
DRAWN: ERRB
CHECKED: JSW
VERSION: A
SCALE: 1"=2,000'
PROJECT NUMBER
ODOJ0000-0023
DRAWING FILE:
SVEM1ODOJ00000023_VICINITY.mxd
SHEET NO.
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OF 14

Narrative Report

This narrative report outlines the field and processing methodology used by David Evans and Associates, Inc. Marine Services (DEA-MS) to collect the data necessary to derive the Ordinary High Water (OHW) and Ordinary Low Water (OLW) boundaries along the Willamette River in Oregon.

Due to the complex nature of the shoreline, several different hydrographic and topographic survey techniques were employed. To determine OHW, DEA-MS surveyed the river banks with a mobile laser scanner. To determine OLW, a combination of multibeam and singlebeam bathymetry was used in conjunction with the mobile laser scanner.

Field Procedures

All data was collected in Oregon State Plane – North Zone (NAD83, CORS96, Epoch 2002) using the Columbia River Datum (CRD) as the vertical reference. Due to limitations with some components of the acquisition system, the data was collected in meters, with final deliverables converted to international feet.

Positioning

Horizontal positioning was accomplished with Real-Time Kinematic (RTK) GPS during acquisition. An RTK base station was set at existing DEA-MS control point "DEMSI" with corrections broadcast to the survey vessel via radio telemetry. The base station was also configured to log the raw GPS observables for later post-processing of the data.

Table 1: Base Station Control

Base Stations	Coordinates NAD83(CORS96, Epoch 2002) ARP		
	Latitude	Longitude	Ellipsoid Height (m)
DEMSI	45º 36' 59.91795" N	122º 38' 26.25951 W	-0.344

Water levels were also determined during the survey with RTK GPS. A critical component for any hydrographic survey using GPS heights is a separation model from the reference ellipsoid to the chart datum. Detailed models of the relationship between chart datum and an orthometric height are required to transform ellipsoid heights to water level data above CRD. DEA-MS developed a model based on recent adjustments to CRD relative to NAVD88 by the U.S. Army Corps of Engineers. Using GEOID03 and these adjustments, the ellipsoid height from a GPS receiver can be converted in real-time to CRD by the acquisition software, or in post-processing. This model has been approved by NOAA's Office of Coast Survey (OCS) and was used on a NOAA mapping project of over 80-miles of the Columbia River and 17 miles of the Willamette River to update the nautical charts.

During survey operations, the vessel also logged raw GPS observables that could be later post-processed. The logging formats varied on the two survey vessels used to complete this project and are discussed later in this section.

Prior to each day's data collection, a confidence check was made on a secondary control point by decoupling the RTK antenna from the vessel, placing it on a fixed length staff and occupying the control point. The real time horizontal and vertical position was then compared to the record value and verified. In all cases, the surveyed position of the check point was within approximately 0.1 feet of the record position in both the horizontal and vertical.

Mobile Laser Scanner Data Collection

A Riegl LMS-Z390i mobile laser scanner was used to map both OHW and OLW boundaries. The system was installed on two different survey vessels, the 20' *Motion Marine* and 31' *John B. Preston*. Each vessel is an aluminum monohull fitted with custom equipment mounts and complete survey navigation and computer system. The scanner was configured to line scan mode and mounted facing to the starboard with the scan width set at 40º above and below the horizontal. The system records 800 points in one line scan, and completes approximately 12 scans per second.

The most vital measurements in a mobile laser scanning survey are heading and roll angles. To account for vessel heading, heave (vertical movement), pitch and roll, an Applanix POS/MV motion reference sensor was utilized. By using vessel speed over ground and heading data provided by GPS, the POS/MV can isolate horizontal accelerations from vessel turns and provide highly accurate motion data. The POS/MV system was also used to record vessel heading (yaw) from which the scanner's beam orientation was derived. The POS/MV provides a higher degree of accuracy for heading measurements than a conventional gyrocompass. The inertial sensor also provides a high level of accuracy during intermittent losses of GPS signals, such as would occur passing under bridges. Raw GPS and inertial data were also logged by the POS/MV for later post-processing.

To calculate the alignment angles between the scanner and the POS/MV reference frame, a boresight alignment was completed. This consists of a series of lines in a specific pattern collected over fixed structures that isolated specific misalignments. These lines were run prior to the initial data collection, and any time the scanner was removed from the vessel.

Table 2: Laser Boresight Alignment Correctors.

Date	Vessel	Roll	Pitch	Yaw	Latency
07/10/2009	S/V Motion Marine	0.60°	0.00°	0.89°	0.00 sec
02/18/2010	S/V Preston	-0.32°	-0.60°	0.00°	0.00 sec
05/13/2010	S/V Preston	-0.32°	-0.60°	0.00°	0.00 sec

During laser scanning operations high resolution digital photography was also collected. A Nikon D300S with a calibrated 20mm lens was automatically triggered to image every 2 seconds while an event was recorded in the POS/MV. This event captured the position and attitude of the vessel at the instant of the photograph. Data was used later to assist in editing data points.

Real-time navigation and data recording was accomplished in Hypack Hysweep version 2009a software. Data specifically targeting OHW was collected from the survey vessel *Motion Marine* on July 10th, 2009 during the mid summer "leaf on" period, and survey vessel *Preston* on February 18th, 19th and 25th, 2009 during late winter when vegetation that may block the laser return off the ground was at a minimum. Additional data targeting OLW was collected on May 13, 2010 during a period of low water.

Multibeam Data Collection

To map the OLW line where a larger vessel could safely maneuver, a multibeam bathymetric system was used on the survey vessel *John B. Preston*. Soundings were acquired with a Reson SeaBat 8101 multibeam bathymetric sonar using a frequency of 240 kilo-Hertz (kHz). The system records 101 soundings in a single sonar ping and is capable of firing up to 20 pings per second in shallow water.

Multibeam data was collected by running lines parallel with the bank in areas that were safely navigable by the vessel. For this survey, the sonar head was mounted with 15° starboard angle to allow for maximum coverage of side slope areas. This enabled coverage over a range of 90° from nadir (straight down) to starboard and 60° from nadir to port with a recorded depth every 1.5°. Vessel draft readings were made off draft markings established on the multibeam mount indicating the distance from the acoustic center of the head to the water surface.

As with the mobile laser scanning survey, the accurate measurement of vessel attitude and heading is crucial. The POS/MV system was also used during multibeam operations to provide vessel position, heave, pitch, roll and heading. The raw observables from the GPS and Inertial Measurement Unit (IMU) were also recorded for later post-processing.

The navigation and survey control system was a personal computer running Hypack MAX version 2009a software. Hypack Hysweep software and Triton ISIS were used for multibeam and sensor data acquisition. Hypack MAX software allowed the swath bathymetric data to be displayed as a painted color image in a "matrix" on the navigation screen. This real-time display gave the hydrographers immediate indications of data quality and coverage to the desired OLW line.

Prior to the start of each day of multibeam survey operations, or after any changes to the configuration were made, data was collected along a series of controlled transects to be used for checking the alignment and system latency of the survey equipment. After analysis during data processing the following correction values were determined and applied during data processing.

Table 3: Multibeam Patch Values

Date	Roll	Pitch	Yaw	Latency
04/01/2010	0.46°	1.50°	0.20°	0.00 sec
04/30/2010	-0.56°	0.75°	-0.30°	0.00 sec
05/01/2010	-0.52°	0.60°	-0.10°	0.00 sec

Detailed measurements of the sound velocity profile through the water column are crucial in multibeam surveys. Changes in the velocity profile will not only affect acoustic distance measurements, but can also cause refraction or bending of the sonar path as it passes through layers in the water column with different velocities. An AML SV-Plus was used to measure the speed of sound of the water column. A total of nine sound speed casts were made during survey operations. The casts showed a generally well mixed water column with consistent sound speeds during each day of data collection. Speeds did vary from day to day however. On April 1st, a slight lens in the upper 3-4 feet increased the velocity to approximately 1441 m/s, while the lower depths were generally 1440.5 m/s. On April 30th and May 1st, the speed had increased to approximately 1451 m/s.

To verify the draft measurement and ensure that the sonar system was reporting depths properly, a bar check was completed prior to the survey. This was accomplished by suspending a metal plate 3 meters below the water surface at the nadir beam of the sonar. The resulting depths, when corrected to the water surface, were less than 0.1 feet from the fixed bar depth.

Multibeam data was collected on three days: April 1st and 30th and May 1st. Although every attempt was made to time acquisition with spring freshet, low water levels at the times of survey limited the areas that the vessel could safely navigate. As a result, the OLW boundary could not be measured in many areas and a different approach was required.

Singlebeam Data Collection

In areas that were difficult to access with the multibeam vessel, DEA-MS's custom 19' aluminum river sled with a jet drive was used to measure OLW. It was outfitted with an ODOM CV100 high precision digital singlebeam echosounder, Trimble SPS750Max RTK GPS receiver and Hypack MAX acquisition system.

Draft measurements were made on the sonar pole and sound velocity casts were taken periodically with a SeaBird Electronics SBE-19*plus* Conductivity Temperature and Depth (CTD) sensor.

To ensure that the sonar system was reporting depths accurately, a bar check was completed prior to each day of survey. A flat bar target was held at varying depths below the water surface at the single-beam transducer. The bar was held at 1-meter to verify draft, and 10-meters to verify the sound speed entered in the echosounder. All recorded depths agreed with the fixed bar depth within 0.1 feet.

Raw GPS observables were logged in the Trimble SPS750Max as a redundant dataset if RTK corrections were not able to be received.

Singlebeam data was collected on May 17th, 18th and 20th timed with the highest tides during each day. Water levels did not reach anticipated levels, and the coverage was limited to only slightly above OLW.

Processing Procedures

Mobile Laser Scanner Data Editing

Initial post-processing of laser data was conducted utilizing Caris Hydrographic Information Processing System (HIPS) software version 7.0, SP1. Boresight alignment data was analyzed and alignment corrections were determined and applied. Applanix POSPAC-MMS software was used to refine and improve the final vessel navigation and attitude solution which is applied in Caris HIPS. This software post-processes the raw GPS and IMU (Inertial Motion Unit) data to produce a "smoothed best estimate of trajectory" (SBET) using advanced forward and backward filtering algorithms. These navigation solutions are considered more accurate than stand-alone RTK positions, both horizontally and vertically. The data was then exported from Caris HIPS as a full resolution data set in ASCII format for input into Microstation for use with the Terrascan application.

To determine the bare earth return and locate OHW a macro within Terrascan was created to allow for an automated approach to enter many files at once. This macro also assured that the files were constrained to their proper placement relative to each other and the survey datum's used. The setting of the variables is determined based on type of project, data density, environment and vegetation type.

During the processing, Terrascan inputs and filters out points that do not meet the macro's requirements. It does this by analyzing the distance and angle between points and point density. After the macro has run it's processes a visual QC is performed to confirm the automated results. The visual inspection assures that extraneous low points or excessive vegetation is removed from the final data classification. The final ground classified data set is then exported as an ASCII file for import into Terramodel for final contouring.

Supplemental laser data collected to aid in OLW classification was processed in a different manner. Only a small band from the water surface up was cleaned. The digital photography was used while editing the points in Caris HIPS subset editor. The hydrographer manually rejected erroneous measurements and any data that was collected over man made structures, such as pilings or docks.

Data intended for OLW determination was exported out of Caris HIPS as a full resolution dataset, with CRD as the vertical datum. Since OLW is defined as a single value on the Willamette River on the National Geodetic Vertical Datum of 1929, 1947 Adjustment (NGVD29/47), it was necessary to convert the datum. Corpscon version 6.0.1 and the VERTCON94 model was used to convert the points from CRD to NGVD29. The final full resolution points on NGVD29/47 were imported into Terramodel for final contouring.

Multibeam Data Editing

Post-processing of multibeam data was conducted utilizing Caris HIPS software version 7.0, SP1. Patch test data was analyzed and alignment corrections were determined and applied. Velocity profiles were used to correct slant range measurements and compensate for any ray path bending.

Applanix POSPAC-MMS software was used to refine and improve the final vessel navigation and attitude solution. This software post-processes the raw GPS and IMU (Inertial Motion Unit) data to produce a "smoothed best estimate of trajectory" (SBET) using advanced forward and backward filtering algorithms. These navigation solutions are considered more accurate than stand-alone RTK positions, both horizontally and vertically.

Particular attention was paid to the area surrounding the OLW contour. Data editing began by filtering the data to remove any soundings below the 12' depth contour. This allowed for a more focused analysis of the data just above and below OLW. Man made and natural structures, piles, piers, and submerged trees, were then removed to the mud line and noise in the water column removed using Caris HIPS Subset Editor.

Data was exported from Caris HIPS at full resolution then imported into Hypack and gridded to a resolution of 0.5 meters using inverse distance weighting algorithms to produce a regular average depth surface. This surface was then imported into Terramodel for final contouring.

Singlebeam Data Editing

Singlebeam bathymetric data was processed using Hypack MAX software. The Hypack system allows simultaneous viewing of the echogram along with the digitized trace collected in the field. Water-level data computed by the RTK GPS was applied to adjust all depth measurements to CRD.

Processing began with review of each survey line using Hypack single-beam editor. Verified water surface correctors were applied to the data set at this time. Position and sensor data was reviewed and accepted. Sounding data was reviewed and edited for data flyers. Sounding data, including sonar beams reflecting from sediment in the water column or noise due to aeration in the water column, were carefully reviewed before flagged as rejected.

Exported data was thinned using Hypack's sort routine to a 3.3-foot density and imported into Terramodel for final contouring.

Data Modeling

Terramodel version 10.60 was used to generate the final contour for Ordinary High Water and Ordinary Low Water elevations. The various data sets were imported into Terramodel and a Digital Terrain Model (DTM) was generated using a Triangular Irregular Network (TIN) to connect the data points.

The Ordinary High Water DTM was generated using only the mobile LIDAR final data set generated from Terrascan. The Ordinary Low Water DTM was generated using a combination of all data acquisition methods. The lack of accessibility to the Ordinary Low Water elevation, due to existing structures, vessels at berth and unusually low water conditions, required some areas to be interpolated between the data sets collected for this project. Multibeam data collected in the summer of 2009 for NOAA charting updates were also utilized to supplement the data sets collected for this project. During the generation of the DTM very experienced personnel carefully scrutinized the data sets and created break lines to control the DTM modeling process to ensure the most accurate representation of the data in the area for the specified elevations of OHW and OLW.

Ordinary High and Low Water Elevations Used

The elevations used for Ordinary High Water (OHW) are from the U.S. Army Corps of Engineers, Portland District (USACE), based on the Columbia River vertical Datum (CRD) and are listed in Table 4. The elevations are referenced by river miles of the Willamette River and listed to a resolution of one tenth of a foot. The OHW is on a gradient along some areas of the river and the elevation used for this project between the river miles with transitioning elevations, is the mean between each river mile as listed in Table 4. The elevations for Ordinary Low Water used for this project were scaled from a profile drawing prepared by the Oregon Division of State Lands, dated March 1975. The elevation scaled from the drawing profile is 4.5 feet NGVD29(47).

Table 4: OHW and OLW elevations

Units are in Feet Willamette River Mile	OLW CRD	USACE OHW CRD	NGVD 29(47) OLW	NGVD 29(47) OHW
0	3.10	15.20	4.50	16.78
1	2.98	15.10	4.50	16.71
2	2.86	15.00	4.50	16.65
3	2.75	14.90	4.50	16.59
4	2.79	14.90	4.50	16.61
5	2.78	14.90	4.50	16.63
6	2.77	14.90	4.50	16.63
7	2.76	14.90	4.50	16.64
8	2.75	14.80	4.50	16.55
9	2.74	14.80	4.50	16.56
10	2.73	14.80	4.50	16.56
11	2.72	14.80	4.50	16.56

Table 5: Project OHW and OLW elevations

ELEVATIONS USED FOR THIS PROJECT Units are in Feet Willamette River Mile	NGVD 29(47) OHW	NGVD29(47) OLW
1-2	16.69	4.50
2-3	16.62	4.50
3-8	16.57	4.50
8-11	16.56	4.50
11-12	16.55	4.50

Deed Research

The riparian boundaries were determined by deeds and by the Tideland Acts of 1872 and 1874 as noted on survey. Much of the deed research was provided by the Oregon Department of State Lands (DSL).

Mapping Existing Conditions

The Ordinary High Water and Ordinary Low Water lines from the DTMs were simplified using ESRI ArcInfo software. Using the Bend Simplify Algorithm with a reference baseline of 5 meters, extraneous bends of the lines were removed while maintaining the line shapes. All topological errors (such as line crossing and overlapping) were removed in this process.

GIS tax lot data from Metro's Regional Land Information System (RLIS), published May 5, 2010, was used as the parcel basemap for this project. The riparian boundaries of the GIS tax lot lines were adjusted using the high and low water lines, as well as calculated deed lines. Only the riparian boundary lines of these parcels were adjusted. Areas obscured by ships and other obstacles which prevented survey access have been identified and labeled on the maps.

Background imagery is from the US Department of Agriculture, National Agriculture Imagery Program (NAIP) 2012, and is provided for cartographic reference only.

Mapping Historical Riparian Lines

The historical riparian lines were derived from a digital reproduction of the US Coast and Geodetic Survey map, titled Columbia River Sheet No. 6 Fales Landing to Portland, issued May 1888 (referred to as the 1888 map). The digital reproduction was received from the Archives of the Historical Map and Chart Collection of the National Oceanic and Atmospheric Administration (NOAA).

The 1888 map was also used by the City of Portland, Bureau of Planning, to develop a GIS dataset titled "1888 Willamette River Depths.[1]" In the production of this dataset, the City of Portland registered a TIF image of the 1888 map to current (2001) maps using street intersections visible in both the historic and current (2001) imagery. The City of Portland then manually digitized the 1888 river depth soundings as points. These digitized points, representing depths, were used to create a triangulated irregular network (TIN) model of the river bathymetry. The TIN model was used to create a 10' x 10' elevation grid, which was then smoothed and subsequently used to develop river depth polygons contained in the "1888 Willamette River Depths" GIS dataset.

For this exhibit David Evans and Associates, Inc. (DEA) used Latitude and Longitude grid ticks to align the 1888 map with other maps ranging from 1852 to 1995. The original georeferencing was conducted in ESRI ArcMap, using the geographic coordinates of the North American Datum of 1927 (NAD27). ESRI software was then used to transform the maps from NAD27 to NAD83 geographic coordinate system. After completing this process, the maps drawn prior to 1909 appeared to have a consistent shift when compared to later maps. To correct this shift, the pre-1909 maps were then readjusted using common lines of the maps. Readjustment lines included PLSS lines and street intersections. Care was taken to use common lines, which appeared precisely mapped on all sets of maps.

Subsequent to the final georeferencing of the maps, digital GIS lines were traced on the 1888 map to represent ordinary high water (OHW), ordinary low water (OLW), drainages, and piers/dikes. The OHW, drainages, and piers/dikes were traced along bold lines drawn on the original map. The OLW lines were traced along the 0 depth stippling lines, where shown, and along the bold lines where the OLW and OHW lines were coincident.

14 points, identifiable on both the 1888 map and current sources (2011 USDA NAIP Aerial Photos or USDA Digital Raster Graphics of USGS Quad Maps), were analyzed to develop a best estimate of accuracy for the 1888 map. The points selected for comparison included features that were verifiable and appeared on both data-sources. Points included Public Land Survey System Section Corners, Donation Land Claim Corners, road intersections, etc. The mean horizontal distance between the points on the 1888 map and the current sources was 57'. After this analysis a 60' buffer was created around the digital lines traced from the 1888 map using ESRI ArcMap. The resulting 120' wide band (60' on each side of the lines) was used to represent the best estimate of where the 1888 lines were located in comparison to existing conditions for the entire Portland Harbor.

Differences between the City of Portland 1888 lines, and the 1888 lines shown in this exhibit, result primarily from differences in methodology. The City of Portland used street intersections to georeference the 1888 map, while David Evans and Associates, Inc. (DEA) primarily used Latitude and Longitude grid ticks. Analysis of the 1888 map by DEA determined that some street intersections shown on the 1888 map were not consistently mapped accurately. The City of Portland used digitized points from the soundings on the map to create a TIN, and subsequently used the TIN to create depth contours, while DEA digitized directly the linework shown on the 1888 map. In general, comparison between the City of Portland's interpretation of the 1888 lines and the lines shown in this exhibit shows the City's lines to be more generalized and to not follow precisely the 1888 map's stippled line of OLW.

Areas of Shoreline Movement

While the 1888 OLW line is depicted as a single, dotted line on the maps, the actual 1888 OLW line falls somewhere within the relevant confidence interval. The Harbor-wide interval (60') was used as an initial screen against which shoreline movement was gauged. (Note: The Harbor-wide interval was not used as a screen along the east side of the Swan Island lagoon in the Mock's Bottom area because the confidence interval was deemed unreliable in that area and substantial fill in that area is well-documented.)

In the initial 2013 riparian mapping, several areas not already resolved by deed in which the 1888 OLW line appeared to be more than 60' from the current OLW line were identified as "areas of shoreline movement." These areas were depicted with cross-hatching between the current OLW line and the 1888 OLW line. In 2013, DSL determined that the current boundary was within the identified area of shoreline movement but did not determine a precise boundary. DSL has since made boundary determinations for all but one of the areas of shoreline movement depicted in the 2013 riparian maps. With that one exception, the cross-hatching depicting areas of shoreline movement has been removed. Cross-hatching is still used to denote an area of shoreline movement at approximate River Mile 9, east side 1N1E17B-00300 and 1N1E18A-00100.

Shoreline movement is presumed to be caused by accretion or erosion in the absence of evidence of an avulsive act that had the effect of moving the boundary. In those areas in which "shoreline movement" is noted, the boundary is presumed to be at the current OLW line pursuant to the Tide Land Grant Acts of 1872 and 1874 except where, and to the extent that, the shoreline movement is determined attributable to an avulsive act(s).

[1] City of Portland. 1888 Willamette River Depths Metadata. http://www.portlandonline.com/cgis/metadata/viewer/display.cfm?Meta_laye r_id=52237&Db_type=sde&City_Only=True

WILLAMETTE RIVER-PORTLAND HARBOR
RIPARIAN LINE MAPPING
OREGON DEPARTMENT OF STATE LANDS
A PORTION OF TOWNSHIPS 2N 1W, 1N 1W, AND 1N 1E
WILLAMETTE MERIDIAN
CITY OF PORTLAND, MULTNOMAH COUNTY, OREGON

DAVID EVANS AND ASSOCIATES INC.
2100 Southwest River Parkway
Portland Oregon 97201
Phone: 503.223.6663

REVISIONS: APPD.

DATE: MARCH 23, 2016
DESIGN: JSW
DRAWN: ERRB
CHECKED: JSW
VERSION: A
SCALE: N/A

PROJECT NUMBER
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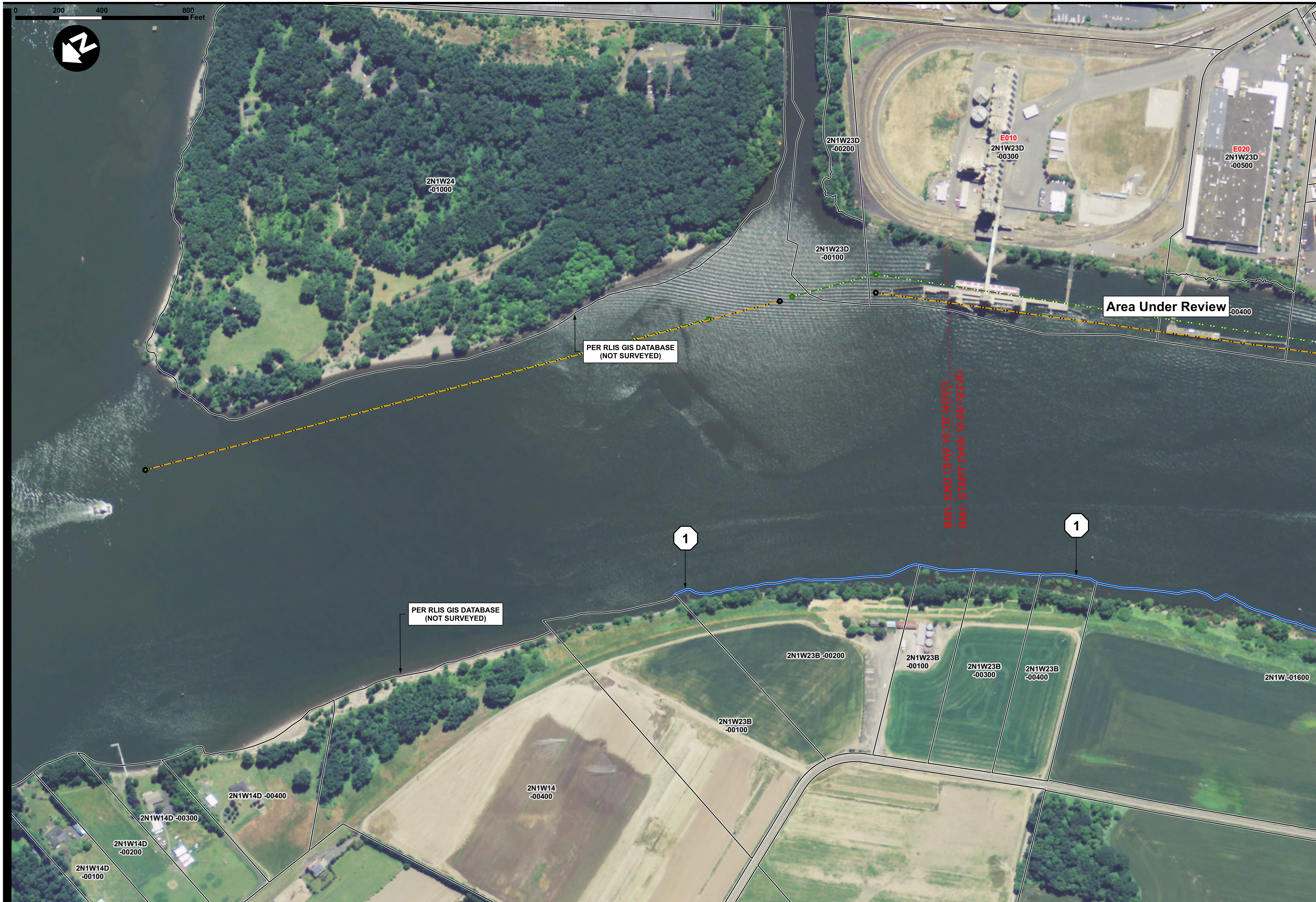

WILLAMETTE RIVER-PORTLAND HARBOR

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OREGON DEPARTMENT OF STATE LANDS

A PORTION OF TOWNSHIPS 2N 1W, 1N 1W, AND 1N 1E

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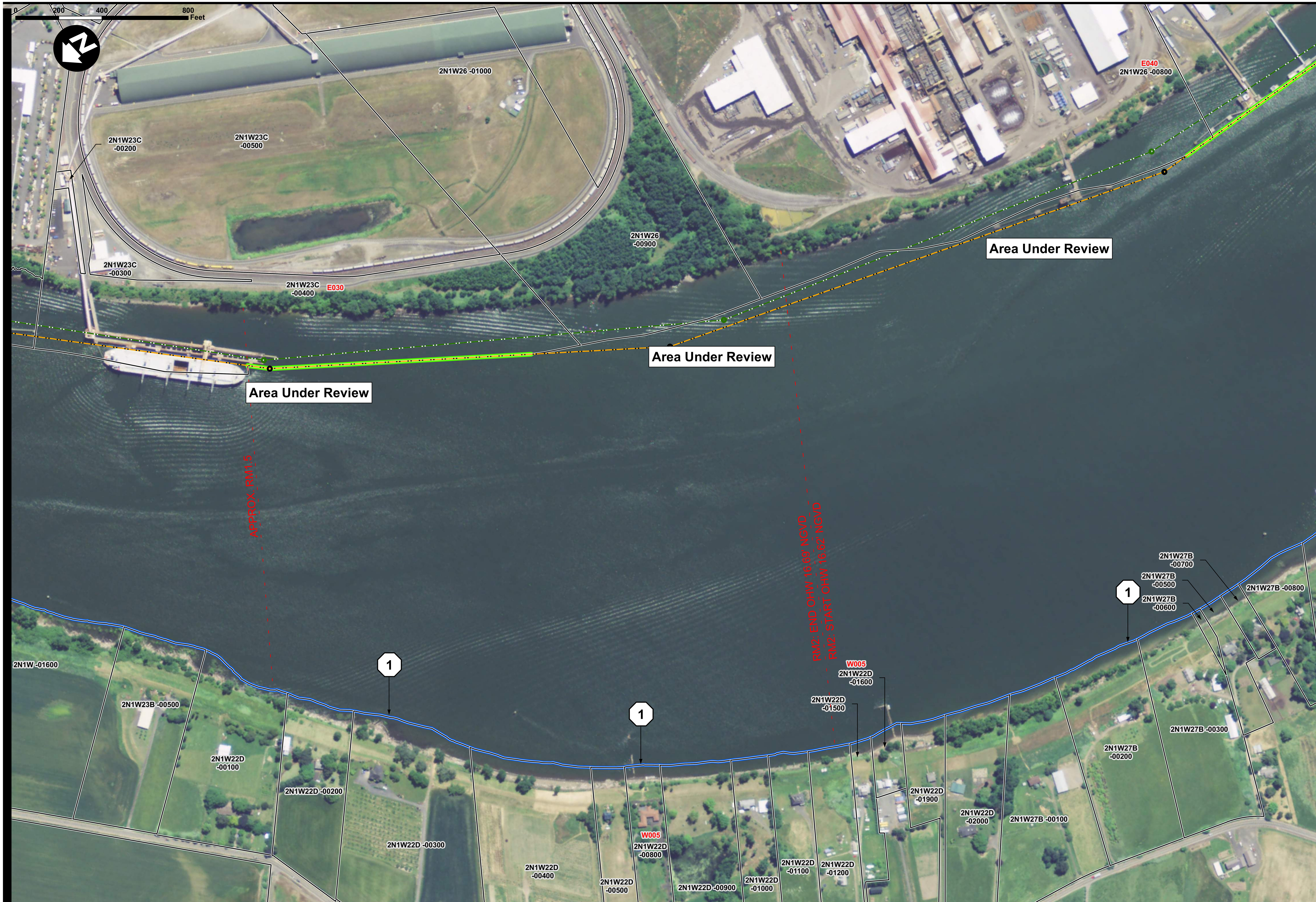

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WILLAMETTE RIVER-PORTLAND HARBOR

RIPARIAN LINE MAPPING

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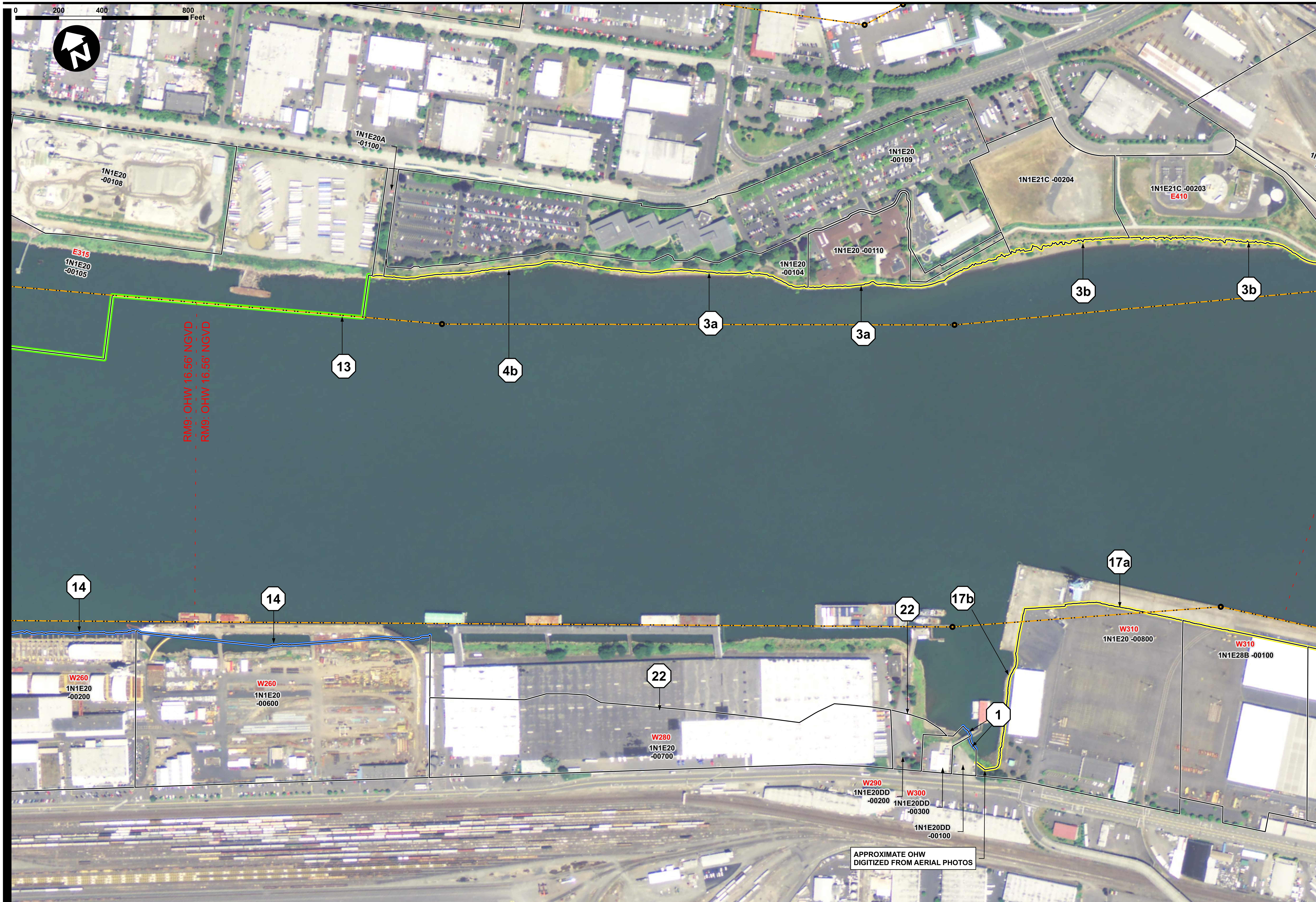

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